# RED ROCK RANCH IFDM PROJECT

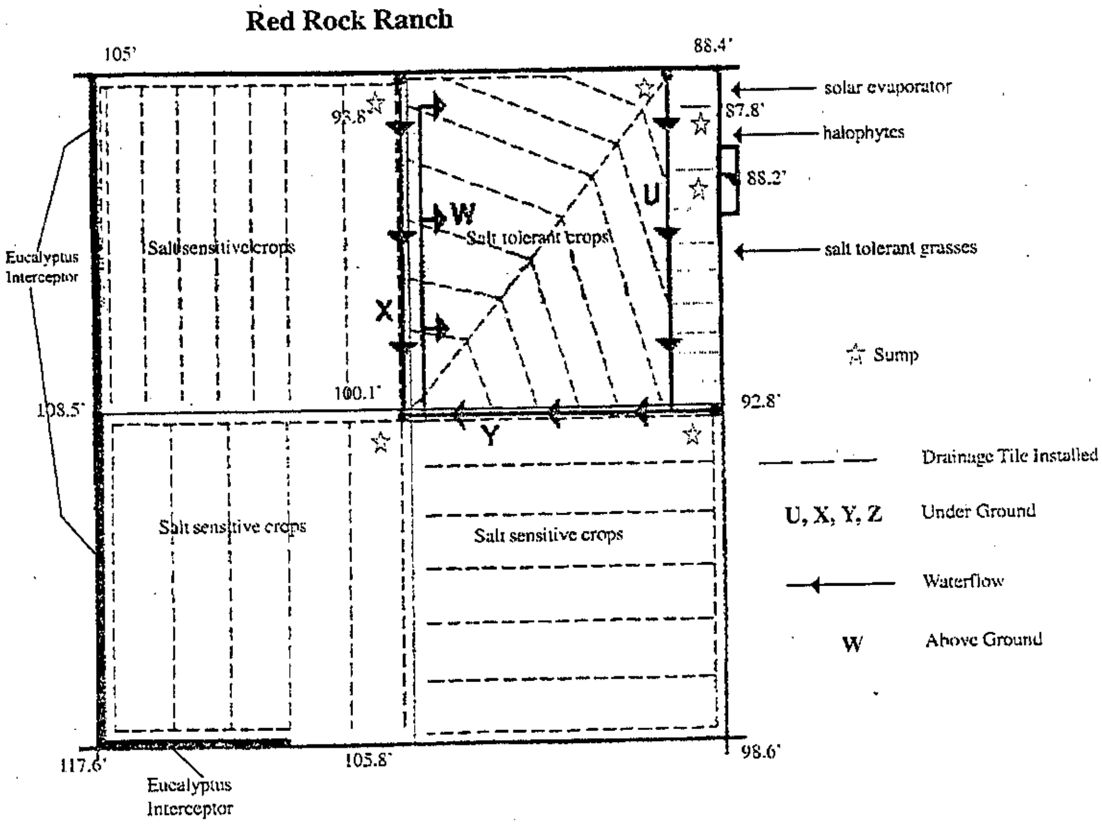
The Red Rock Ranch (RRR) site is located in Fresno County approximately 3 miles south of Mt. Whitney Avenue and 2 miles west of Colusa Road. The site lies in the Westlands Hydrologic area (no. 551.10) in the South Valley Floor Hydrologic unit as depicted in the DWR hydrologic maps. RRR operates in the WRCD and in the Westlands Water District (WWD). The project site lies within the alluvial fan and floodplain of Cantua Creek, east of the California Aqueduct. The predominant soil at the site is Ciervo clay.

The purpose of this project was to demonstrate the effectiveness of IFDM (Integrated on-Farm Drainage Management) to the farming community, regulatory agencies and others. As a result RRR is an important site for further trials of various crops and drainage reuse techniques. This project on 640 acres was designed in the period 1991 to 1994. The system was based upon a sequential reuse saline drainage water to irrigate crops of increasing salt tolerance. The design is partially based upon the "agroforestry demonstration project" near Mendota. Approximately 75% of the farm was set aside for "salt sensitive crops", 20% for "salt tolerant crops", 2% originally for "salt tolerant trees" and later planted to "salt tolerant grasses", 1% each to halophytes and solar evaporator. (See figure 11, a map of the farm showing these areas.)

The drainage waters from each one-quarter section devoted to salt sensitive crops was collected in a sump at the northeast corner of each area. These waters were delivered to the southwest corner of the salt tolerant crops area where it was used to irrigate these crops. Drainage from the salt tolerant crop area was collected in a sump in the northeast corner and this water was pumped and delivered to the salt tolerant grass area. Drainage water from the salt tolerant grasses was collected in a sump and delivered to the halophyte area. Finally, the drainage from the halophytes was collected in a sump and delivered to the solar evaporation pond.

Interceptor tree planting along the southern and western perimeters of the farm began in 1993 and continued until at least 1995, expanding to the 12-acre area set-aside for "salt tolerant trees". In 1995 drainage systems were installed in the southwest ¼, northeast ¼, "salt-tolerant trees", "halophytes" and the "solar evaporator" areas. The drainage system was installed in the southeast ¼ in 1996 and in the northwest ¼ in 1997. Thus, the Red Rock IFDM first operated as a complete "system" in 1998. See the chronology of events on the following pages.

Figure 11: Site Layout for Red Rock Ranch



## Chronology of Events

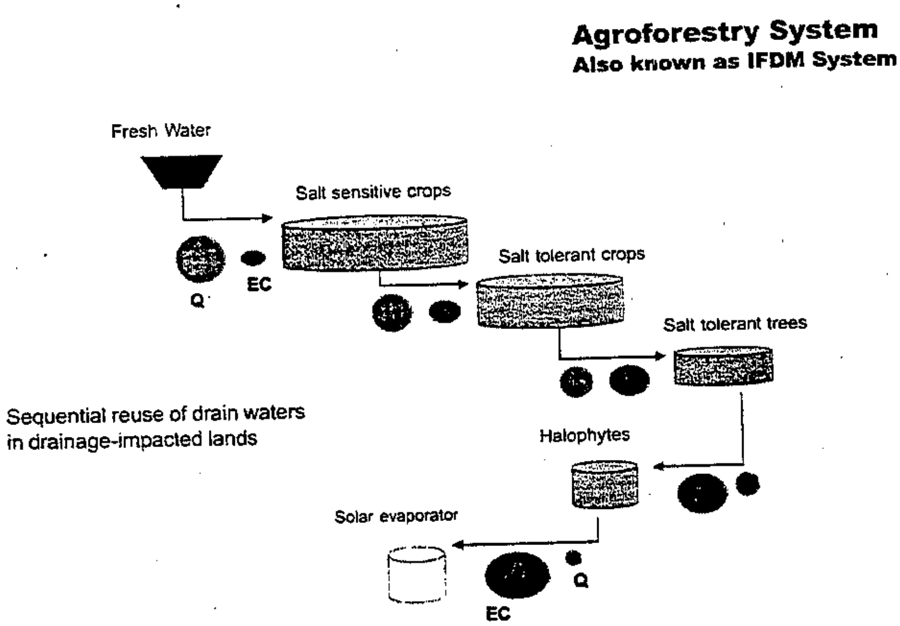
| | |
|---|---|
| 1991-1994 | Field Monitoring and Design Activities |
| 1993-1995 | Tree planting activities |
| 1995 | Installation of drains in NE ¼ (salt tolerant cropping area)<br>Cotton planted in this area<br>Installation of drains in SW ¼ (first salt sensitive cropping area)<br>Wheat then alfalfa planted in this area<br>Installation of drains and monitoring wells in tree and halophyte areas<br>Installation of solar evaporator |
| 1996 | Set up 3 blocks in the NE ¼ (salt tolerant cropping area)<br>Crops: 1. corn. cotton 2. canola, broccoli 3. wheat<br>Installation of drains in SE ¼ (second salt sensitive cropping area)<br>Wheat and tomatoes planted in this area<br>Alfalfa in SW ¼ irrigated to leach salts<br>Installed irrigation timers for solar evaporator and halophyte area<br>Installed sprinkling system for solar evaporator<br>Monitoring of wildlife by USFWS |
| 1997 | Installation of drains in NW ¼ (third salt sensitive cropping area)<br>Wheat then alfalfa planted in this area<br>Trees in salt area are dead, replanted<br>Planting of halophytes<br>Crops in salt tolerant crop area: sugar beets, sugar beets, cotton<br>Salt leaching in alfalfa in SW ¼<br>Corn and broccoli planted in SE ¼ |
| 1998 | Removal of trees and replanting<br>Design of solar still (greenhouse for evaporating drainage water)<br>Land level and divide halophytes into 11 blocks; automatic irrigation<br>Crops in salt tolerant crop area: wheatgrass, alfalfa(seed), sugar beets<br>SW ¼ alfalfa taken out and broccoli cropped<br>SE ¼ safflower, onions<br>NW ¼ salt leaching of alfalfa<br>Only year to date with somewhat complete actual data from site |
| 1999 | Removal of trees and replaced with salt tolerant grasses<br>Crops in salt tolerant crop area: wheatgrass, alfalfa(seed), wheat<br>SW ¼ tomatoes<br>SE ¼ onions<br>NW ¼ salt leaching of alfalfa<br>Additional tree planting on eastern side of salt tolerant crop area |
| 2000 | Installation of solar still |

Crops in salt tolerant crop area: wheatgrass, alfalfa(seed), fallow, cotton
SW ¼ cotton
SE ¼ wheat, tomatoes
NW ¼ salt leaching of alfalfa, later sprayed and replaced
Soil analysis by CSU-Fresno begins
Salt tolerant grasses irrigated with saline drainage water (first time)
Monitoring of wildlife by USFWS

2001 Removal of liner from the solar evaporator area
Crops in salt tolerant crop area: wheatgrass,
SW ¼
SE ¼
NW ¼

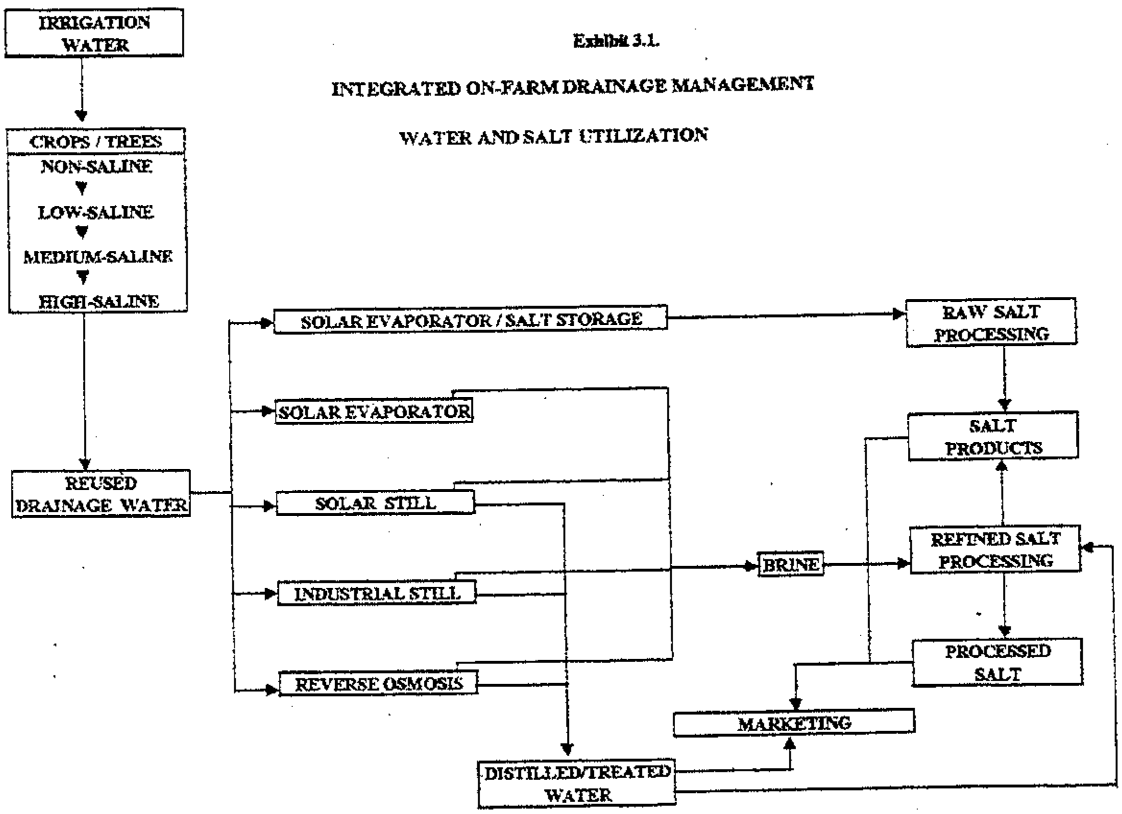
The intention was for each sequential reuse to decrease the volume of drainage water collected and to increase the concentration of salts and selenium. This flow through sequence is shown in Figure 12.

**Figure 12: Sequential Drainage Reuse Chart**



A total IFDM schematic proposal includes other optional operations as diagramed in Figure 13. Only portions of this diagram have been incorporated into RRR.

**Figure 13: Diagram of Complete IFDM System Proposal**




Results for this project are primarily provided in a report dated October, 1999 (Cervinka et al., 1999) and by additional information provided by Cervinka (personal communication), and Westside Resource Conservation District (1996a, 1996b and 1999). The design, projected and actual data are presented in table 5. The "design data", are from exhibit 7.7 and "projected data" are from exhibit 13.7 as presented by Cervinka et al., (1999). The actual data for the years 1995 through 2000 are taken from many sources, but 1998, the most complete information, is from exhibit 13.8 Cervinka et al., (1999). Less complete results were available for the other years except 2000 which have been recently provided electronically. The reason for having some different projected data from design data is not clear. One main difference is that the salt concentration of the initial irrigation water was assumed to be 400 mg/L in the design and 250 mg/L in the projected data. The 250 mg/L is lower than generally reported for irrigation waters in the area, so comparisons between design and results will be presented for the 400 mg/L irrigation water.

# Table 5: Design, projected and actual data from Red Rock Ranch

| | Design Exhibit 7.7 | Projected Exhibit 12.1 | Actual Data by Year below | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | Average |
| **Salt Sensitive Crops** | | | | | | | | | |
| Acres | 480 | 470 | 470 | 470 | 470 | 470 | 470 | 470 | |
| Irrigation Water (Ft.) | 2.5 | 2.5 | | | | 3.5 | 3.2 | 3.0 | |
| Total Volume (Acre-Ft) | 1200 | 1175 | | | | 1650 | 1482 | 1410 | |
| salt concentration (mg/L) | 400 | 250 | | | | | | | |
| *Total Salt Mass (tons)* | 644 | 400 | | | | | | | |
| Tail Water (Ft.) | | 0.4 | | | | | | | |
| Volume (Acre-Ft) | | 188 | | | | | | | |
| *Total Salt Mass (tons)* | | 72 | | | | | | | |
| Leaching Fraction | 10% | 10% | | | | 4.6 | | 4.6 | |
| Leachate Volume (AF) | | 99 | | | | | | | |
| Groundwater Volume | | 25 | | | | | | | |
| Total Drainage (AF) | 120 | 123 | | | | 76.3 | | 64.25 | |
| salt concentration (mg/L) | 4000 | 2755 | 5535 | 12210 | | 9583 | 8203 | 5017 | 8110 |
| *Total Salt Mass (tons)* | 644 | 472 | | | | 959 | | 581 | 770 |
| **Salt Tolerant Crops** | | | | | | | | | |
| Acres | 130 | 130 | 130 | 130 | 130 | 130 | 130 | 130 | |
| Applied Water (Ft. *) | 2.5 | 2.7 | | | | 2.7 | | 1.5 | |
| Volume (Acre-ft) | 325 | 351 | | | | 350 | | 192.8 | |
| salt concentration (mg/L) | 1729 | 1144 | | | | | | | |
| *Total Salt Mass (tons)* | 754 | 558 | | | | | | | |
| Leaching Fraction | 20% | 12% | | | | 7.4 | | 11.2 | |
| Leachate Volume (AF) | | 42 | | | | | | | |
| Groundwater Volume | | 11 | | | | | | | |
| Total Drainage (AF) | 64 | 53 | | | | 25.9 | | 21.07 | |
| salt concentration (mg/L) | '8646 | 8453 | 11205 | 8370 | | 8105 | 7950 | 8730 | 8872 |
| *Total Salt Mass (tons)* | 754 | 624 | | | | 259 | | 227 | 243 |
| **Salt Tolerant Grasses** | | | | | | | | | |
| Acres | 11.65 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | |
| Applied Water (Ft.) | 6 | 4.1 | | | | | | 1.6 | |
| Total Volume (AF) | 64 | 53 | | | | | | 21.1 | |
| *Total Salt Mass (tons)* | 754 | 624 | | | | | | | |
| Leaching Fraction | 25% | 30% | | | | | | 14.8 | |
| Total Drainage (AF) | 16 | 22 | | | | 6.6 | | 3.13 | |
| salt concentration (mg/L) | 34585 | 21652 | 12150 | 13140 | | 14462 | 10788 | 9540 | 12016 |
| *Total Salt Mass (tons)* | 770 | 660 | | | | 118 | | 37 | 78 |
| **Halophytes** | | | | | | | | | |
| Acres | 4.13 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | |
| Applied Water (Ft.) | 4 | 4.4 | | | | 1.32 | | 0.63 | |
| Total Volume (AF) | 16 | 22 | | | | 6.6 | | 3.13 | |
| *Total Salt Mass (tons)* | 770 | 660 | | | | | | | |
| Leaching Fraction | 45% | 38% | | | | 37 | | 132 | |
| Total Drainage AF | 7 | 11 | 4.6 | 3.89 | 3.47 | 2.46 | | 4.12 | |
| salt concentration (mg/L) | 76855 | 43043 | 13095 | 11790 | 11250 | 10966 | 9503 | 10530 | 11189 |
| *Total Salt Mass (tons)* | 762 | 678 | 74.3 | 56.6 | 48.2 | 33.3 | | 54 | 44 |
| **Solar Evaporator** | | | | | | | | | |
| Acres | 1.64 | 2 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | |
| Total Applied Water | 7 | 11 | 4.6 | 3.89 | 3.47 | 2.46 | | 4.12 | |
| *Total Salt Mass (tons)* | 762 | 678 | 74.3 | 56.6 | 48.2 | 33.3 | | 54 | 53 |
| Operational days | | | 135 | 164 | 200 | 109 | | | |

* Applied water a mixture of tailwater, drainage from salt sensitive crops and canal water.

Avg. of Total Salt Mass in Solar Evaporator is for five years, the above figure 44 tons is for only 1998 and 2000.

## Analysis of Integrated Farm Drainage Management

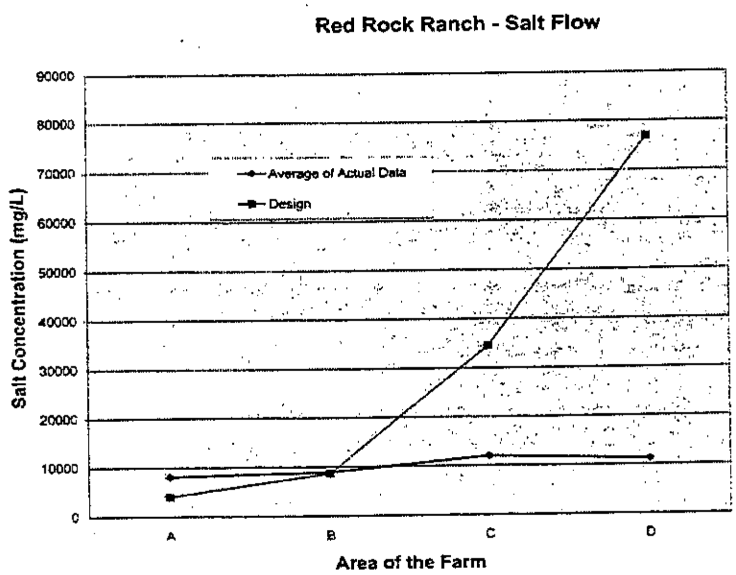
This section will use information from the scientific basis for drainage water reuse section with results achieved on the Red Rock Demonstration Farm. Particular attention will be given to the design criteria to identify adjustments, which should be made in designing new systems.

## Sequential Concentration of Water

The design was based on the water collected in the drainage system being the same concentration as water leaving the root zone. For drainage systems with tile spacings as existed at the Red Rock Ranch, there is considerable travel time (years) for water leaving the root zone from some sections of the field before it arrives in the drainage line. The actual water collected in the drainage system during the first few years of installation will largely reflect the composition of the shallow groundwater. The term shallow in this context however, can refer to tens of feet.

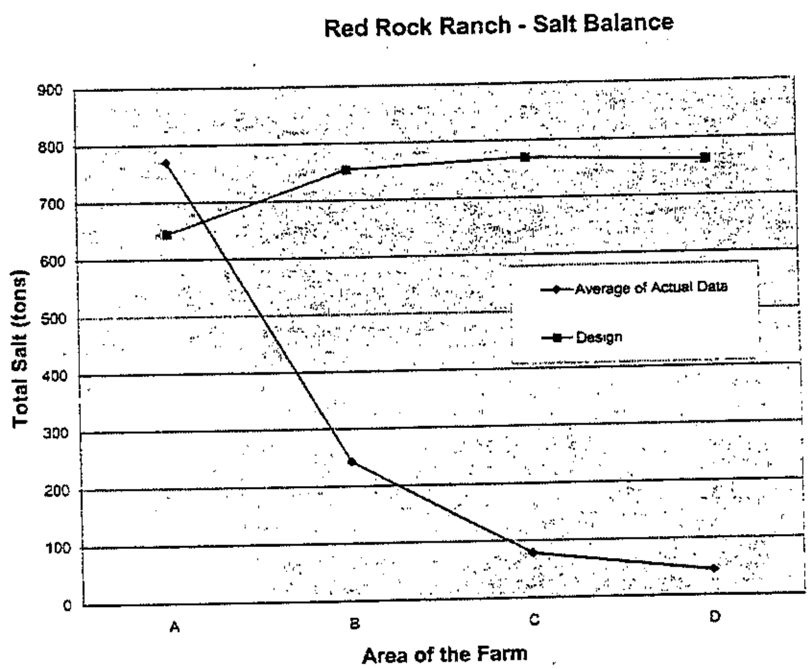
The average salt concentration in the drainage water is reported for every year except 1997. The average salt concentration in the drainage water for the years reported are compared with "design" values in figure 14. The salt concentration in the drainage water leaving the salt sensitive crops is about 2 times greater than the projected value. Note that the sequential average salt concentration in the drainage waters leaving the salt sensitive crop, salt tolerant crop, salt tolerant grass and halophyte areas only increase slightly for the 5 years of reported data. These results are consistent with projections which consider the travel time. The net result is that the projected concentrations and mass of salt moving along the different components of the system far exceeded the actual results. The mass of salt delivered to the evaporator pond represented about six percent of the projected salt mass to the evaporator pond.

**Figure 14. Comparison of designed and measured salt concentration in the drainage water collected from various areas of the farm.**




A-drainage water from salt sensitive crop area B-drainage water from salt tolerant crop area C-drainage water from salt tolerant grass area D-drainage water from halophyte area and placed into the evaporator pond

**Figure 15. Comparison of designed and measured mass of salt in the drainage water collected from various areas of the farm.**




A-drainage water from salt sensitive crop area B-drainage water from salt tolerant crop area
C-drainage water from salt tolerant grass area
D-drainage water from halophyte area and placed into the evaporator pond

The total mass of salts in the drainage water is reported for the years 1998 and 2000. The average total mass for the two years, are illustrated in comparison to the projected values in figure 15. Note that the projected mass of salt remains relatively constant as it moves through the system. In contrast, the measured results indicate a consistent decrease in salt mass as it moves through the system. At the end, only about 6 percent salt is deposited in the evaporator pond as compared to the expected amount. Clearly, a salt balance is not being achieved by the system for scientific reasons, which will be described later.

One might note that the sequential concentration of water at the Mendota Demonstration was much closer to projected figures. Also the concentration after the last use was far higher than that measured at the Red Rock Ranch. Since the Mendota site was the initial demonstration of the sequential reuse, it is understandable why these results would be used in projecting the behavior at the Red Rock Ranch. This raises the question, "what is the difference between the two systems"? The difference is that the Mendota demonstration used relatively small plots with drain lines positioned immediately below the plots. Also a dense clay layer at the 10 to 12 foot depth at Mendota would have restricted vertical flow. Therefore, water collected in the drain line system was much more reflective of the water leaving the root zone. Again, these results clearly identify the importance of considering the travel time in projecting results.

The data for selenium and boron contained in Table 6 are similar to the salt data. Although there is a trend toward increase in concentration with each sequential reuse, the increase is not great. Also the total mass of these chemicals tends to decrease with each sequential reuse.

**Table 6: Boron and Selenium Data for Red Rock Ranch**

| | Se mg/L 1998 | Se mg/L 2000 | B mg/L 1998 | B mg/L 2000 |
|---|---|---|---|---|
| Salt Sensitive Crop | 0.40 | 0.38 | 17.3 | 14.7 |
| Salt Tolerant Crop | 0.47 | 0.58 | 17.0 | 17.5 |
| Salt Tolerant Grasses | 1.32 | 0.53 | 28.0 | 16.7 |
| Halophytes | 0.95 | 0.63 | 21.0 | 19.0 |

| | Se tons 1998 | Se tons 2000 | B tons 1998 | B tons 2000 |
|---|---|---|---|---|
| Salt Sensitive Crop | 0.038 | 0.030 | 1.629 | 1.165 |
| Salt Tolerant Crop | 0.015 | 0.015 | 0.543 | 0.455 |
| Salt Tolerant Grasses | 0.011 | 0.002 | 0.228 | 0.065 |
| Halophytes | 0.003 | 0.003 | 0.064 | 0.097 |

## Crop Selection

The design called for four different cropping systems with increasing salt tolerance ending up with halophytes. Because the salt concentration in the drainage water is approximately the same from all of the drainage systems, there is no need for progressive salt tolerance. Certainly the use of halophytes is not justified because of their generally very low economic return. Furthermore, the drainage water concentrations never reached levels high enough to be most appropriate for halophytes. Indeed there were reports that drainage water from Mendota had to be transported to Red Rock to carry out some of the small scale research projects on halophytes.

Basically, the farm can be divided into only two sections. One section used for good quality irrigation water and another section used for irrigation with drainage water or a combination of drainage and surface waters. Depending upon the flexibility of irrigation water conveyance systems to deliver drainage and good quality waters, either in a blended or cyclic fashion, a fairly wide range of crops could be selected for growing on the portion of the farm devoted to using drainage water.

The model described in the science section could be used to simulate the consequences of various management strategies using various crops and combined use of drainage and surface water supplies.

## Evaporator Pond

The design for the evaporator pond size was done by taking a very conservative estimate on the amount of water that evaporates on an annual basis and the amount of drainage water leaving the halophytes to be evaporated. The concept of an evaporator pond is that water is delivered to the pond at a rate equal to or less than the rate of evaporation. The design approach would have been appropriate if the evaporation rate and drainage discharge were constant throughout the year. The approach would have been valid even if these rates were not constant throughout the year, but the ratios of the two were constant throughout the year. Neither of these assumptions is valid. Therefore, the pond was severely undersized resulting in occasional ponded water in the pond and adjacent halophyte areas causing some bird damage.

The design of an evaporator pond to prevent any ponding is extremely complex. One would need information on the temporal variations in evaporation rate (which could vary annually) and drainage water volume. These data could be used to calculate a pond area that would evaporate all the water delivered daily. This constraint dictates that the pond be large and rather inefficient because much of the time, the potential for evaporation would exceed the rate of discharge.

Another factor, which largely negates the utility of evaporator ponds, is that salts accumulate. They are dissolved, creating a very high concentration, by rainwater collected in the pond. Since rain is associated with low evaporation rate, very concentrated water can exist in the pond for some period of time during a rainy season.

The maximum amount of the water that can be evaporated annually, therefore minimizing the pond size, is achieved by having free standing water in the pond each day. With sequential reuse of drain water a relatively small land area would be required for the farm. Consideration would be required to accommodate rain and the actual drainage reuse plan. With free standing water, bird damage would have to be mitigated by netting the pond.

Another proposed purpose for evaporator ponds was to accumulate "dry" salt so that it could be marketed. This goal would be negated in a pond, which had continual water. Various uses for the salt have been suggested and investigated during recent years. Most attention has been given to the use of sodium sulfate. Examples of potential uses tested are as a component in glass or in dyes. Thus far, no economically practical use has been identified. Although hope of finding an economic use for the salt should not be completely dropped, the probabilities of success appear to be getting very small. Unless this goal is realized, one of the reasons for an evaporator pond is eliminated.

## Long Term Effects

Conceptually, most if not all of the drainage water could be reused for economic crops with the proviso of an appropriate drainage water collection and redistribution systems that would allow for blending or intermittent use with good quality water. This system will work because the salts in the drainage water are put back into the ground; and because of considerable travel time, will not return to the drainage outlets immediately. However because the travel times to the drainage line vary with distance from the drain line, the concentration will gradually and continuously increase. Thus, the salinity of the water to be reused will increase with time and the system will become constrained. Ultimately salt must be removed from the farm or isolated in one segment of the farm to achieve an infinitely sustainable system.

A major policy issue is the trade-off between short-term benefits of reusing water with long-term serious consequences of degrading land. Mesopotamia is the often-repeated classic example about a society that transformed very productive agricultural land into a desert. A consideration that is frequently overlooked is that this transition occurred over centuries of time. Because it took centuries of time rather than decades, was it any less an historical disaster?

## Environmental Issues at RRR

Two environmental issues are pertinent to the Red Rock Ranch project. (1) Standing waters that stimulate invertebrate production and attract birds can be harmful to birds if the water contains only a few micrograms per liter of selenium. (2) Water containing 1 mg/L or more of selenium is classified as being "toxic" and is regulated by the Toxic Pit Cleanup Act. The purpose of this act is to protect groundwater quality.

The Central Valley Regional Water Quality Control Board (CVRWQCB) in 1994 issued waste discharge requirements (WDR's) to the Diener Family Trust and the Westside Resource Conservation District (WRCD). One condition of this permit was biological monitoring of the site because of potential impacts to wildlife by the high concentrations of selenium anticipated to be discharged into the solar evaporator. California Department of Water Resources (DWR) biologists have been monitoring the site since the permit was issued in 1994. US Fish and Wildlife Service (USFWS), personnel have also been monitoring the site, but on a more sporadic basis.

Wildlife information for the RRR site has been provided in a conversation with Joe Skroupa of the USFWS and from reports by the DWR. DWR staff visits are more of an observational nature than analytical. The permit issued by the CVRWQCB requires no standing water is to be allowed in the drainage reuse and solar evaporator portions of the project. Ponding of water is prohibited in the solar evaporator for the two following reasons:

1. It provides attractive aquatic habitat that is high in selenium. Birds feeding in such water would likely demonstrate teratogenic and other reproductive defects.
2. Discharge to the RRR solar evaporator often exceeds 1 ppm Se. Water equal to or in excess of 1 ppm Se can not be ponded in this manner as it would be a violation of the Toxic Pits Cleanup Act (TPCA).

Joe Skorupa (personal communication, Feb. 21, 2001) reported performing extensive observation and egg collecting in 1996 at RRR. The main bird species being studied was Black necked stilt. Fifty-six percent of the embryo's examined were deformed and only two percent of the eggs were viable. This is the highest rate of Se induced avian teratogenesis reported at any site in the world. In 1996, the eggs had an average of 58 mg/kg selenium. The selenium concentration in the drainage water for that year was reported in the ranged from 1041 to 1214 mg/L. Puddles in the solar evaporator were reported to have over 11 mg/L Se. Skorupa was unable to make routine visits to the site from 1997 to 1999. He collected two to four eggs during this period, which was not enough for a clear statistical sample.

Clu Cotter of the DWR made frequent visits to the site in 1998, stating his purpose was to look primarily for impacts to shore birds. These impacts would come from ingesting invertebrates that were living in the halophyte plots or the solar evaporator. Most importantly, he checked for invertebrates in standing pools of water. Water standing for more than three days can harbor a large number of aquatic invertebrates. His second purpose was to comment on the water management and operation of the Zon propane guns to disturb the nesting birds. Cotter reported that he did not see any invertebrates in the solar evaporator at RRR. There were fewer water management problems at RRR than at the Mendota site, primarily due to the automatic operation of the sprinkler system. He did see one aquatic invertebrate in a pool in the halophyte plots on one occasion. (WRCD report, January 1999)

In 2000, funding was again established for more complete monitoring by the USFWS. Between April 2000 and March 2001 a total of 24 biological site monitoring visits were made to RRR. During the year 2000, nesting by thirteen species of birds was documented in the RRR drainage management area, including 84 nesting attempts. (not including the salt sensitive crop area) 149 eggs were collected and analyzed, 79 of which contained assessable embryos, only 4 of which had abnormalities. These abnormalities were judged to be only one-tenth the levels found in 1996. The species of concern, black necked stilt, had 2 of 37 abnormalities, both of which were presumed to be due to selenium.

Only partial results of selenium analysis were available from eggs collected. The LAWR laboratory did analyze 4 of the stilt eggs and obtained an average of 16 ppm Se on a dry weight basis, this compares favorably to 58 ppm found in 1996. However, Skorupa cautioned that these eggs were collected early in the breeding season, when the solar evaporator was flooded with rainwater, and he anticipated eggs collected later would contain higher levels.

DWR staff observed 14 species of birds at RRR in 2000. Small mammal burrows and amphibians were also observed at the site. This work is continuing. On April 22, 2001, twelve species of birds were observed at the site, by a DWR environmental specialist. Two house finch nests were found under the cover of Zon cannons at locations in the solar evaporator and the halophyte plots. The surface, of the solar evaporator and the halophyte plots, was dry to the extent that wind gusts were causing dust and salt to blow off these areas. The salt tolerant grass plots were damp with a few scattered small puddles, but no invertebrates were observed or nesting sites located in this area.

### Contributing Factors to Environmental Problems

No provision for drainage water storage was made except for the sumps. Because the change in elevation across the fields, the drain lines on the upper end of the field are at higher elevations than the land surface elevation at the lower end of the field. (Figure 11) Water will flow into drainage lines as long as the water table is above the drain line. Once in the drain line, the water flows rapidly to the sump and can "flood" the lower end of the field.

During some winter months, the amount of water collected in the last two sumps exceeded the capacity to be discharged on the halophyte area and into the evaporation pond without free standing water. The result was some embryo abnormalities and violation of the Toxic Pits Cleanup Act.

### Mitigating Options

Options to reduce wildlife hazard and meet environmental regulations are available. Control valves on drain line laterals to restrict flow in the line would allow water storage capacity in the soil to be utilized. From the total farm perspective the amount of salt, selenium, boron and water collected in the last two sumps is very small.

Recycling this water onto the salt tolerant crops and salt tolerant grass areas would only marginally increase the amount of salt and boron distributed to these areas and have very little impact on productivity.

**Utility of the Toxic Pits Cleanup Act**

The enactment of the TCPA was not motivated by a problem associated with selenium. Nevertheless selenium has become ensnared in the regulation. Human made laws should be evaluated as to whether they accomplish the purpose for which they were enacted. In this case the purpose was to protect groundwater quality.

Ponding water is not in violation of the TPCA if the selenium concentration is less than 1 mg/L. One might assume that 1 mg/L is the concentration at which water become "toxic". Yet concentrations several orders of magnitude lower can cause wildlife damage. Wildlife must be protected from water with concentrations much lower, so wildlife damage would not be any greater from waters more concentrated than 1 mg/L. From a wildlife perspective, TCPA is irrelevant. The drinking water standard is ~~10~~ 50 micrograms per liter, thus from a drinking water standard is also irrelevant.

Therefore, prime consideration is given to groundwater protection. Selenium percolates downward to ground water from which it was extracted in the first place. Furthermore, most of the selenium in evaporation ponds has been measured to be in the sediment and relatively small layers immediately below the pond. Relatively small amounts of selenium percolate downward to groundwater from these sources.

The results at Red Rock Ranch reveal that more than 90% of the selenium in the drainage water extracted from the salt sensitive crop area has already been returned to the land and possibly to the groundwater. Less than 10% ends up in the pond that would be protected by the TCPA. Thus, the Toxic Pits Cleanup Act has very little impact upon the resultant groundwater quality. However, it does impose some potentially very costly facilities to meet compliance.